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*Cover Photo by Malak*: Grain Elevator at Port Arthur.

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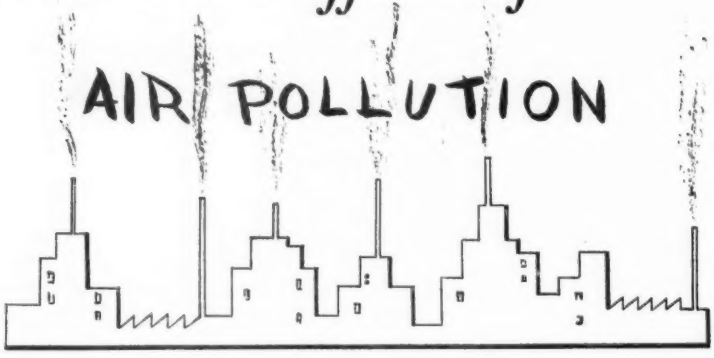
# *Some toxic effects of* AIR POLLUTION *on Public Health*



**BY MORRIS KATZ*, M.Sc., Ph.D.**

Air pollution is fast becoming a community problem of major importance in many parts of the civilized world. Contamination of the atmosphere on an increasing scale has become associated with the growth of large urban centres and the rapid expansion of industrial and transportation facilities. In recent years, a series of acute air pollution episodes, resulting in illness and deaths from protracted smog visitations, has emphasized the graver aspects of uncontrolled emission of waste products. The acute effects on health follow a recognizable and familiar pattern whenever intolerable concentrations of smoke, sulphur dioxide, and other air pollutants are built up under adverse meteorological conditions such as prolonged temperature inversions. Usually, however, more subtle influences on public health are involved in the chronic effects of day-to-day exposure to low concentrations that may lead to eye irritation, mild bronchitis or merely absorption of small quantities of impurities by the respiratory tract.

Before due consideration can be given to some of the toxic effects of air pollution, it is advisable to review, briefly, the nature and composition of substances that pollute the community atmosphere. These substances may be divided broadly into two classes:

(1) Gases or vapours;
(2) Particulate matter, consisting of both liquid and solid particles over a wide size range, from relatively coarse particles of less than 100 microns in diameter, down to aerosol particles in the respirable sizes of less than seven microns to those of submicron dimensions.

We may define community air pollution as a condition of the ambient atmosphere that is due to the presence of substances, liberated by the activities of man, in concentrations sufficient to interfere directly or indirectly with his comfort, safety or health, or with the full use and enjoyment of his property. This definition rules out such natural sources of pollution as volcanic activity, dust storms, combustion products of forest fires, airborne pollen, bacteria, plant spores and agents of communicable disease. It is also beyond the scope of this paper to deal with the pollution caused by radio-active waste products from nuclear reactors or bomb tests.

The maintenance of a reasonable state of air purity is essential to all human and animal life. The average adult requires about 15,000 to 20,000 quarts of fresh air per day, or 10 times as much by weight as the total amount of food and water consumed daily. Nevertheless, we have not yet become accustomed to the preservation of air purity to the degree that is considered to be necessary for our food and water supplies.

### *Nature of Pollution*

Only a relatively small number of compounds have been identified, thus far, among the thousands of substances that pollute the air as a result of man-made activities. Some of the difficulties involved in the isolation and identification of these substances are due to their complexity, the low concentrations in which they occur, their labile nature and the fact that many volatile or gaseous products are strongly absorbed on the coexisting aerosol particles.

Waste products of one sort or another are discharged to the atmosphere in every type of fuel-burning operation, incineration, or manufacturing process. Among the major sources may be listed: the combustion of coal, oil and gas for power generation, steam and heating purposes; the combustion of gasoline and other fuels in internal com-

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TABLE I — Atmospheric Contaminants

| Gases and Vapours | | Particulate Matter | | | |
|---|---|---|---|---|---|
| Inorganic | Organic | Miscellaneous Coarse Dust | Smoke and Tarry Organic Material | Other Aerosols | |
| | | | | Inorganic | Organic |
| 1. Sulphur oxides<br>2. Hydrogen sulphide<br>3. Oxides of nitrogen<br>4. Nitric acid<br>5. Ammonia<br>6. Hydrofluoric acid and volatile fluorides<br>7. Chlorine and hydrochloric acid<br>8. Carbon dioxide<br>9. Carbon monoxide<br>10. Ozone | Aliphatic and aromatic hydrocarbons<br>Ozonides and peroxides of hydrocarbons<br>Organic products of photochemical reactions<br>Aldehydes, ketones, alcohols, acids, ethers, esters and oxides.<br>Organic halides, nitro-compounds, sulphonic acids, and phenols.<br>Amines and other miscellaneous volatile organics. | Silica<br>Alumina<br>Clay<br>Fly ash<br>Iron oxides<br>Calcite<br>Gypsum<br>etc. | Anthracene<br>Phenanthrence<br><br>Polynuclear aromatic and carcinogenic hydrocarbons of the pyrene, benzanthracene, fluoranthene series, etc. | alkali metal compounds,<br><br>heavy metals and a variety of inorganic oxides, carbonates, chlorides, fluorides, nitrates and sulphates | oily and solid organic material,<br><br>heterocyclic compounds, proteins and other organics of high molecular weight. |

bustion engines for transportation purposes; oil refining and petrochemical processes; iron and steel production; smelting and refining of ore concentrates; the production of chemicals, food products, pulp and paper, cement and fertilizers, solvents, paints, plastics, and many other products.

The tabular summary (Table I) indicates some of the contaminants that are present in the urban atmosphere as definite chemical entities or as cations, anions, and other class groups of relatively unknown composition. Of these substances, the gases and vapours are normally present in the atmosphere in concentrations of less than one part per million parts of air by volume (p.p.m.), with the exception of carbon dioxide and carbon monoxide. Carbon dioxide is not usually considered to be an atmospheric contaminant, except under special environmental conditions, because of its role in the photosynthesis of green plants. The most common gaseous contaminants in community air are carbon monoxide, sulphur dioxide, oxides of nitrogen, hydrocarbons, aldehydes, and ozone or "oxidants".

The maximum concentrations of a number of air contaminants measured within recent years in Los Angeles County, which has experienced a persistent and troublesome smog problem, are shown in Table II.

Of course, such peak concentrations represent unusual smog conditions even in the Los Angeles area. The average levels of contaminants are considerably lower. However, comparable maximum concentrations of sulphur dioxide in excess of 1 p.p.m. have been reported on occasion in many other large cities, including Windsor-Detroit, New York, Chicago, Philadelphia, and Toronto, and in cities of the United Kingdom, such as London, Glasgow, Birmingham, and Manchester. Unusually high levels of ozone or oxidant have been found to occur in Los Angeles County due to the peculiar photo-chemical characteristics of Los Angeles smog but such contaminants, in lower concentrations, have also been reported in San Francisco, Windsor-Detroit, New York, Washington, and other urban centres. Sulphur dioxide, in varying amounts, is liberated in the combustion of coal, oil, and other fuels and in the smelting of sulphide metal concentrates. The most prolific source of carbon monoxide, hydrocarbons, aldehydes, and oxides of nitrogen is the exhaust gas from the numerous automobiles, trucks, and buses operating on city streets and roads.

A considerable amount of information on the concentrations and composition of particulate contaminants in city air has become available in studies of the Windsor-Detroit international pollution problem under the terms of a reference to the International Joint Commission and from results of the United States National Air Sampling Network. The average concentration of airborne particulate matter varies roughly in proportion to population. Thus, in cities of over two million in population, the average particulate matter concentrations vary from about 200 to over 350 micrograms per cubic

TABLE II — Maximum Concentrations of Air Contaminants in Los Angeles County (From Report of Engineering and Planning Division, Los Angeles County Air Pollution Control District, July 1958)

| Contaminant | Concentration p.p.m. | Location | Date of Occurrence |
|---|---|---|---|
| Total aldehydes | 1.87 | Pasadena | 30/5/57 |
| Carbon monoxide | 72.0 | Downtown L.A. | 3/12/57 |
| Total hydrocarbons | 4.66 | El Segundo | 11/8/57 |
| Nitrogen dioxide | 1.74 | Downtown L.A. | 17/9/53 |
| Nitric oxide plus nitrogen dioxide | 1.86 | Dominguez | 12/12/57 |
| Total oxidant | 0.69 | Downtown L.A. | 13/9/53 |
| Ozone | 0.90 | Vernon | 13/9/55 |
| Sulphur dioxide | 2.49 | El Segundo | 27/6/57 |

metre of air. Those with populations between 500,000 and two million show average atmospheric concentrations in the range of more than 100 to about 180 micrograms per cubic metre. However, atypical dust loadings may be evident in communities that are relatively small but are dominated by a strong dust source of either industrial or natural origin.

Insofar as the composition of this complex mixture of substances, characterized as airborne particulate matter, has been studied by analytical, spectrographic and other techniques, there are in evidence certain similarities and also qualitative differences in fractional components from one city to another, probably indicative of dominant sources of pollution. For example, the filtered dust may be separated into acetone-soluble or benzene-soluble organic material, a protein fraction, and substances that contain more than 20 metal elements in the form of oxides, carbonates, chlorides, and fluorides, sulphates and nitrates. There is also present a well-defined polycyclic hydrocarbon fraction that contains small amounts of compounds possessing toxic carcinogenic properties such as benzpyrene, di-benzpyrene, benzanthracene, and others. In particulates collected from the Windsor-Detroit atmosphere, the following metal elements have been found by spectrographic analysis, in descending order of abundance: calcium, aluminum, silicon, iron, magnesium, lead, zinc, manganese, copper, titanium, tin, tungsten, chromium, molybdenum, barium, bismuth, nickel, antimony, cadmium, vanadium, and beryllium.

As an indication of the major influence of traffic gas from the operation of more than 2.5 million vehicles in Los Angeles County, this area has the highest concentration of acetone-soluble particulate matter and nitrate ion in comparison with other large metropolitan complexes such as New York, Chicago, Philadelphia, Detroit and San Francisco in the United States National Air Sampling Network. Furthermore, average lead concentrations in air are relatively greater in those large cities having populations of two million or more than in smaller urban centres, presumably due to the increased consumption of automotive fuel, among other factors.

Within recent years, an increasing number of polycyclic hydrocarbons have been identified in the particulate phase of urban air and in that of exhaust products from gasoline and diesel engines by Kotin, Falk and Thomas, Commins, Shore and Katz, Moore and Katz, and Lyons and Johnston among other workers. Of these compounds, a number are known to be carcinogenic on the basis of animal tests, including 3,4-benzpyrene; 3.4-benzofluoranthene; 1,2,3,4-dibenzopyrene and 1, 2,4,5-dibenzopyrene. These toxic compounds are formed in the incomplete combustion of solid, liquid, and gaseous fuels, in association with smoke, soot and tarry material. Their presence has lent support to the theory of the existence of an aetiologically significant factor in epidemiological studies of the greater incidence of lung cancer in urban over rural populations.

### *Acute Health Effects of Air Pollution*

The harmful effects on public health of a marked increase in atmospheric pollution during prolonged periods of fog have been established beyond a shadow of doubt. The City of London, England, has experienced a series of lethal fogs, accompanied by relatively high levels of smoke and sulphur dioxide, and greatly increased mortality and illnesses over periods of four to five days. The following episodes have been recorded since 1948.

Apparently, an important feature of the more recent London smog episcdes has been the rise in the death rate on the first day of the fog at a time before the atmospheric pollution has attained its maximum. This would suggest that many other smog visitations of shorter duration may be associated with a definite mortality which may not be large enough to become obvious through mortality statistics. The view has been expressed that in a London fog if the pollution exceeds the critical level of about four times the customary winter average, the resultant effect on public health will cause

TABLE III — Occurrence and Mortality of London Fogs (Ministry of Health, United Kingdom)

| Date | Estimated Mortality Increase |
|---|---|
| November 26 - December 1, 1948 | 700-800 |
| December 5 - 8, 1952 | 4000 |
| January 3 - 6, 1956 | approx. 1000 |
| December 2 - 5, 1957 | 763-1000 |

an immediate, marked increase in mortality. Thus far, only air-borne particulate matter (smoke) and sulphur dioxide have been measured on a systematic basis in the London atmosphere, but there is no doubt that many of the other common pollutants associated with fuel burning, industrial and transportation activities would also accumulate under the inversion blanket to correspondingly high levels.

In the United States, the most dramatic air pollution incident involving public health occurred during the five-day fog that enveloped Donora, Pa., on October 26 to 29, 1948. As a result of the accumulation of coal smoke, sulphur dioxide, and other contamination under the heavy inversion layer, 5,910 persons or 42.7% of the town population became ill and 20 died. A thorough study of this episode by the United States Public Health Service (U.S.P.H.S.) failed to disclose that any single pollutant could have caused these drastic effects on health and it was concluded that the illnesses and deaths were due to a synergistic factor involving several or more contaminants whose joint action was apparently much greater than the mere additive effect of each taken separately.

There have been earlier episodes of this type in London but it is sufficient for our purpose to mention one other well-known disaster ascribable to air pollution. This was the Meuse Valley, Belgium, incident of December, 1930, described in the report of the Commission assigned to investigate its causes and effects. A prolonged inversion due to anticyclonic weather conditions, accompanied by an unusual increase in pollution levels, led to the deaths of 60 persons and an undetermined number of illnesses that may have mounted in the thousands.

These air pollution disasters show many common features as to the meteorological conditions that led to the abnormal increase in contaminant concentrations and in the resultant symptoms and manifestations of the affected populations. The complaints of those who became ill included throat irritation, cough, shortness of breath, nausea, dyspnoea, cyanosis, bronchospasm, and vomiting. In the majority of illnesses and fatal cases were persons who were elderly or had a history of pre-existing cardiopulmonary or respiratory conditions which might increase their susceptibility to atmospheric irritants.

Other air pollution effects on public health which may be classed as acute, even though the manifestations are not as severe as those described above, have come to the attention of health authorities within recent years. In Yokohama, Japan, a considerable number of United States servicemen and their dependents were affected by periodic outbreaks of asthma that required hospitalization or medical care. Most of these people had not suffered from asthmatic conditions previously. These recurrent asthmatic outbreaks were found to be correlated with wind directions that would tend to carry specific industrial emissions over this community. Remarkably similar occurrences have been reported quite recently in New Orleans, La. In these cases, however, the affected persons were known to be sufferers from asthma, but the episodes took place at times associated with specific wind direction and velocity. The observed effects could not be caused by pollen or other common allergens.

The close association of these acute health symptoms with abnormal air pollution levels during three- to four-day periods of inversion or fog is a remarkable, though incontrovertible, fact. Illnesses and deaths begin to rise within one day after the onset of such episodes. They reach a peak about the time that maximum concentrations of pollution are attained and thereafter drop off, although less rapidly, as the pollution levels decrease sharply with the breakup of the smog visitation when fresh, clean air is swept into the area.

During a three-day period of atmospheric stagnation in the Detroit-Windsor area in the early part of September, 1952, pollution concentrations rose to unusually high levels. Many complaints of eye irritation and respiratory discomfort were made by residents in the area. A study of mortality records for the area revealed a striking rise in infant mortality and in deaths of individuals with malignant disease during this period.

Some significant findings have been reported as an aftermath of the Donora smog episode of 1948 in a study made recently by the Graduate School of Public Health of the University of Pittsburgh. Information was obtained on the incidence during 1948 to 1957 of certain chronic conditions, including cardio-respiratory symptoms, hospitalization and medical services received, occupation, smoking habits, cause of death and other essential factors on over 4,000 residents of Donora previously surveyed by the U.S.P.H.S. It was found that persons who suffered acute illness at the time of the smog epsode have experienced higher prevalence of illness and greater mortality than other persons living in Donora at that time. There is some evidence in this study that greater mortality and morbidity are related to the effects on the cardio-respiratory system. Persons who had a history of chronic cardio-respiratory disease prior to the 1948 smog episode, irrespective of whether they suffered acute illness during this episode or not, have demonstrated the highest subsequent mortality.

### *Chronic Health Effects of Air Pollution*

The demonstration of chronic effects of air pollution on public health is an extremely difficult problem as it concerns much more subtle influences related to the long-continued exposure of community populations to fluctuating concentrations of smoke, dust, sulphur dioxide and other acid gases, hydrocarbons and other organics, and many other substances. The occasional manifestations of irritation to the eyes or throat may not seem of sufficient import to the average urban dweller to arouse concern. Attempts at derivation of statistically significant findings from epidemiological studies of morbidity in selected sample populations are beset with difficulties due to the many factors that may have to be taken into account. However, evidence on this aspect of air pollution is steadily accumulating as the methods of investigation become more refined.

With the passage of Public Law 159 in 1955 by the 84th Congress to provide for technical assistance and research on air pollution, U.S.P.H.S. has intensified its efforts to study the health aspects of community air pollution along statistical, epidemiological, and biological laboratory lines of investigation. This has resulted in marked progress in medical research and in knowledge of the variations in concentration levels of the air in many urban areas and the nature of some of the more toxic pollutants. A comprehensive effort is being made to develop indices of air pollution in their relation to health.

Mortality statistics covering 163 cities within the United States have been studied in the development of correlation coefficients between 50 causes of death and various air pollution indices which included city size by population, degree of industrialization, population density, gasoline service station sales as an index of total potential exposure to traffic pollution, fuel consumption, and others thought to be related to air pollution. Some preliminary information on the results to date have been presented recently by Manos and Fisher and by Prindle. Of all the causes of death, four disease conditions were found to show high positive correlations with most of the indices, especially those which might relate to increasing air pollution. These diseases were cancer of the trachea, bronchus, and lung; cancer of the stomach and esophagus; arteriosclerotic heart disease, including coronary disease, and chronic endocarditis (not specified as rheumatic) and other myocardial degeneration. Some of the data reported by Dr. R. A. Prindle of U.S.P.H.S. are shown in Tables IV and V to illustrate the correlation with only two of the air pollution indices, city size by population and population density per square mile of metropolitan area.

With respect to mortality among white males due to the above four diseases in correlation with the consumption of various types of fuel as a source of air pollution, it was found that the value of the correlation coefficients is in general consistently higher for stomach cancer than lung cancer, and higher for these two causes than for the other two diseases. Service station sales or gasoline consumption, on the other hand, correlate better with lung cancer than with the other three diseases. In the study of extent of industrialization as related to the four causes of death, the correlation value of specific industries, ranked according to their air pollution potential, shows that these industries may

TABLE IV — Median Values of Mortality Ratios for Selected Causes of Death by Size of Metropolitan Area
(after Dr. R. A. Prindle, U.S. Public Health Service)

| Size of Area U.S. | Number of Cities | Malignant Neoplasm of Trachea, Bronchus and Lung 162-163 | Malignant Neoplasm of Esophagus and Stomach 150-151 | Arteriosclerotic Heart Disease Including Coronary Disease 420 | Chronic Endocarditis Not Specified as Rheumatic and Other Myocardial Degeneration, 421-422 |
|---|---|---|---|---|---|
| | | | White Male | | |
| 50,000- 99,000 | 15 | 1.10 | 1.04 | 1.19 | 0.89 |
| 100,000-199,000 | 56 | 1.34 | 0.94 | 1.30 | 0.88 |
| 200,000-299,000 | 31 | 1.30 | 1.03 | 1.26 | 1.06 |
| 300,000-399,000 | 14 | 1.56 | 1.11 | 1.24 | 1.00 |
| 400,000-499,000 | 9 | 1.60 | 1.07 | 1.35 | 0.86 |
| 500,000-599,000 | 13 | 1.61 | 1.15 | 1.29 | 0.92 |
| 600,000-999,000 | 10 | 1.64 | 1.09 | 1.38 | 0.72 |
| 1,000,000+ | 15 | 1.89 | 1.41 | 1.38 | 1.10 |
| | 163 | | | | |

TABLE V — Median Values of Mortality Ratios for Two Causes of Death by Population Density

(after Dr. R. A. Prindle, U.S. Public Health Service)

| Population Density per Square Mile for Metropolitan Area | Number of Cities | Malignant Neoplasm of Trachea, Bronchus and Lung, 162-163 | Malignant Neoplasm of Esophagus and Stomach 150-151 |
|---|---|---|---|
| 1-14 | 22 | 1.17 | 1.07 |
| 15-19 | 29 | 1.40 | 0.90 |
| 20-29 | 37 | 1.35 | 0.97 |
| 30-39 | 21 | 1.45 | 1.07 |
| 40-49 | 14 | 1.46 | 1.06 |
| 50-99 | 26 | 1.68 | 1.09 |
| 100+ | 14 | 1.85 | 1.42 |
| | 163 | | |

be suspected to be a much greater hazard in the production of cancer of the trachea, bronchus, and lung and to a lesser extent in the case of cancer of the stomach and esophagus.

However, statistical data of this type are considered by Prindle to indicate only the need for further study and research. There is, as yet, no evidence to support an assumption or a causal relation between these diseases and air pollution. The distribution of deaths may be affected by many factors which are only partially accounted for or neglected completely in this type of survey. Obviously, a direct comparison with actual concentration levels of contaminants in the environment of these metropolitan areas would be highly desirable, but such data are available on a limited basis in only a relatively small number of such communities at the present time.

The clinical syndrome known as chronic bronchitis is being linked with air pollution as evidence of a circumstantial nature mounts steadily. In England and Wales, chronic bronchitis and its related condition, known as emphysema, account for more illnesses and deaths than all other respiratory diseases. Pemberton and Goldberg of the University of Sheffield discovered a highly significant correlation between bronchitis mortality and average sulphur dioxide concentration in a survey of mortality rates for a number of communities in England and Wales in 1951. A comparison of morbidity and mortality trends for bronchitis in middle-age groups with environmental conditions in the United Kingdom by Fairbairn and Reid showed that the data correlated highly with a simple air pollution index based on atmospheric visibility. Other studies by Reid and by Lawther lead to the conclusion that air pollution, as measured by the levels of smoke and sulphur dioxide, shows a remarkable correspondence with morbidity rates from bronchitis and that this disease is definitely aggravated by a rise in pollution levels, particularly during the winter months.

It is only recently that medical authorities in North America have shown an awakening of interest in the possible relationship of chronic bronchitis and emphysema to atmospheric pollution or the irritating effects of excessive cigarette smoking. Differences in methods of diagnosis between British and American medical practitioners may be, in part, responsible for the lack of an American counterpart to the chronic bronchitis syndrome of Great Britain. The climate, the widespread use of relatively low-grade solid fuel for domestic heating and the density of population and industry may account for the strong association of air pollution with this disease in the British Isles. On the basis of mortality statistics alone, the prevalence of chronic bronchitis in the United States is very much less than that in the United Kingdom, although its frequency has been increasing in recent years, both in Canada and the United States.

The irritating action of sulphur oxides and other acid gases, ozone or oxidants, nitro-olefines and certain aerosols on sensitive body tissues and membranes may be considered as one of the more subtle forms of the chronic effects of air pollution on health. In the Los Angeles area, for many years, recurrent smog visitations have caused eye irritation to many residents, as well as serious economic damage to agricultural and fruit crops and accelerated cracking of rubber goods. It has been established that these effects are not due to the primary pollutants in the state that they are liberated to the atmosphere, but to their subsequent photochemical interaction, in the presence of sunlight, to yield much more harmful reaction products. Thus, hydro-carbons, especially olefines and diolefines of the $C_4$ to $C_7$ series, react readily with ozone to form ozonides and peroxides of the hydrocarbons. The ozone is formed during the irradiation of oxides of nitrogen in sunlight. Both hydrocarbons and oxides of nitrogen are discharged in relatively large quantities with the exhaust gas of motor vehicles. Nitro-olefines may also be produced in the atmosphere of the Los Angeles Basin, although their presence as such has not been demonstrated.

Nitro-olefines have been found to be exceedingly toxic to animals and these injurious effects are intensified by such stress factors as high humidity and temperature. In low concentrations, approximating theoretically the levels that could be encountered in the air of the Los Angeles Basin, nitro-olefines produced symptoms of eye irritation on the investigators.

Other recent laboratory studies indicate that ozone, in concentrations lower than those previous-

ly considered injurious, has been shown to produce scarring of the lung tissue and fatal pulmonary edema in experimental animals subjected to daily exposures over a period of months.

Dautrebande, Shaver and Capps, in a study of the sensory response of human subjects to the constituents of Los Angeles smog, found that the presence of aerosols of sodium chloride, oil, or smoke increased greatly the degree of irritation produced by sulphur dioxide, formaldehyde and other gaseous pollutants.

Amdur of the Harvard School of Public Health has developed a sensitive method for the evaluation of the respiratory response of experimental animals to relatively low concentrations of irritants. This involves the measurement of the resistance to the flow of gas into and out of the lungs and airway. An increase in resistance is indicative of bronchial constriction such as that experienced by an asthmatic patient. Both sulphur dioxide and sulphuric acid may produce significant increases in resistance to pulmonary flow, the magnitude of which is dependent upon the concentration of irritants present. However, a mixture of sulphuric acid mist of sub-micron particle size and sulphur dioxide caused a degree of response that was far greater than could be accounted for on the basis of the simple additive effect of the two contaminants. This was not the case when the sulphuric acid mist was administered in the form of larger particles of 2.5 micron diameter. Furthermore, the response to sulphur dioxide was also increased in the presence of sub-micron particles of sodium chloride which were inert alone.

This potentiating effect was found to be much greater at low concentrations than at higher concentrations of sulphur dioxide. Thus, at higher concentration ranges, the sulphuric acid mist was uniformly equivalent to 15 to 20 times that concentration of sulphur dioxide, but, in the lower concentrations, a level 0.5 p.p.m. of sulphuric acid mist was equivalent to 60 p.p.m. of sulphur dioxide. Although the complete explanation of this potentiating or synergistic factor is not clear at present, the results indicate that the adsorption of irritant gas on an aerosol of sub-micron size may cause enhanced adverse effects due to the creation of high local concentrations in the lung tissue and the resultant increase in the amount of gas reaching the alveoli.

The above studies on the potentiating influence of solid or liquid aerosols, which may be inert in themselves, in the production of markedly increased effects of irritant gases on lung functions point the way to a new understanding of air pollution toxicology. Sulphur dioxide, sulphuric acid mist, aldehydes, smoke, and small particles of oil, salt, silica and many other aerosols and gases are common constituents of urban smog. A considerable proportion of the aerosol particles are present in the respirable size range of less than five microns to below 0.1 micron. The synergistic effect of the interaction of irritant gases and respirable aerosols under the exposure conditions of prolonged inversions and fog provides a hypothesis that may lead to a solution of the complicated toxicology of air pollution disasters.

In an attempt to determine the more subtle influences of air pollutants, U.S.P.H.S. is sponsoring research on the effects of various acid gases, salts of these gases, ozone, hydrocarbons, and nitro-olefines on enzyme and other biological systems. Tissue culture technique is being applied to the study of various cell preparations, generally of human origin, in order to determine the changes in growth, reproduction, and metabolism under the influence of air pollutants. It has been shown that certain toxicants have an adverse effect on muscle contraction and leucocyte metabolism. In other experiments on the development of pulmonary edema from exposure to ozone concentrations, it was found that there occurred a simultaneous decrease of certain enzymes in the affected lung tissue, including alkaline phosphatase.

#### *Cancer and Air Pollution*

Interest in the possibility of certain forms of cancer being associated with air pollution has been stimulated by the great increase in the frequency of lung cancer in many countries in recent years. Although a considerable body of statistical information points to cigarette smoking as one of of the causal agents, it is known from other statistics that in urban areas with high air pollution levels the cancer rate is higher than in rural areas or small towns where air pollution levels are of lower intensity. Reference has been made earlier in this paper to the recent data presented by Prindle, which indicate that mortality rates for cancer of the trachea, bronchus, and lung increase with rise in population density per square mile for various metropolitan areas in the United States. The death rate for this type of cancer among white males increases with increasing size of metropolitan area, on the basis of population, even when the percentage of regular smokers among these males remains substantially constant.

In a comprehensive review of the environmental causes of lung cancer, Hueper has marshalled an impressive weight of circumstantial evidence that points to a number of environmental factors, acting in varying degrees and combinations, as the contributory cause to the development of pulmonary cancers and as being involved in their phenomenal

rise in frequency. Statistical studies of the sex distribution of lung cancer in many countries have revealed consistently higher incidence of this type of cancer in males than in females. The male to female ratios of lung cancer have shown remarkable variations in geographic space and time and in different demographic groups. There is absolutely no doubt about the marked and growing predominance of males over females among lung cancer victims. The facts concerning industrial-regional and urban-rural differences in lung cancer frequency, as well as male-female ratio, may be quite readily accounted for by a hypothesis based on the action of environmental carcinogens. The possibility of exposure to such carcinogens has been greatly enhanced by the growth of industrial establishments and urban development, increasing utilization and complexity of chemical and other manufactured products, and the accelerated rise in motor fuel consumption.

In the last decade, an increasing number of polynuclear aromatic hydrocarbons, some of them of proven potency as animal carcinogens, have been identified in the urban atmosphere and in the exhaust gases of gasoline and diesel engines. Other carcinogens are present in coal tar, asphalt, bituminous coal and petroleum products, isopropyl oil, effluents of industrial and domestic furnaces and in dust from rubber tires, asphalted and oiled roads. There are also known occupational, respiratory carcinogenic agents associated with industries involving arsenicals, asbestos, chromite, radioactive dust and gases, tar distillation, and many others. It has been estimated that about 16 mg of 3, 4-benzpyrene may be inhaled and retained in the lungs from urban air pollution during a life-time. This quantity, represents a dose approximately 40,000 times greater than that capable of producing cancer in mice by subcutaneous introduction (0.4 micrograms). Since the benzpyrene content of urban air may be increased fourfold during smoggy days and this compound is only one of an increasing number of carcinogenic compounds isolated from atmospheric pollution, the actual total of such substances accumulated in the lungs would be very much greater. According to Hueper, the much greater incidence of lung cancer in males over females may be due to the relatively greater number of males employed in occupational activities, both indoor and outdoor, involving exposure to contaminated industrial or urban atmospheres. Males predominate in tasks that require heavy physical labor, in motor and other transportation activities, in iron and steel, mining and smeltng and other heavy-industry occupations where exposure to carcinogenic pollutants is greater. Females, on the other hand, spend a larger portion of their lives in the cleaner air of suburban communities.

It is of interest to mention that U.S.P.H.S. is currently engaged in an investigation of the carcinogenic potential of the particulate matter collected from the air of nine cities of the United States. This study will provide some significant information as there are relatively wide variations in lung cancer frequency for these nine cities.

In the meantime, studies of cancer, mortality, and air pollution in the United Kingdom by Stocks have shown a relatively high degree of correlation between lung cancer mortality and smoke concentration of the atmosphere. Although lung cancer is highly correlated also with population density, it would appear that smoke is an important contributor to the excess of lung cancer found in large towns in England and North Wales. A statistically significant, second-order correlation exists between smoke concentration and lung cancer even when population density is held constant. Suggestive evidence was presented by Stocks of the independent association of lung cancer with the polycyclic aromatic hydrocarbons, 1, 12-benzperylene and 3,4-benzpyrene, whether measured on the basis of concentration per unit weight of smoke or per unit volume of air.

These polycyclic hydrocarbons occur in the community atmosphere in very small amounts and are associated with the smoke or particulate matter. In measurements made at 23 sampling sites in urban and rural districts of North Wales, Cheshire and Lancashire, as part of a cancer survey in 1956-1957, Commins found that the average pyrene concentrations varied between 0.2 and 8.2 micrograms per 100 cu. m. of air, and those of fluoranthene, benzpyrene and benzperylene were between 0.4-6.9, 0.1-6.8 and 0.1-20.8, respectively.

Values of a similar order of magnitude have been reported by Moore and Katz in particulates collected at a site in downtown Montreal, Canada, as shown by the data in Table VI. On a comparable basis of the amount of hydrocarbons in parts per

TABLE VI — Polycyclic Aromatic Hydrocarbons in Smoke and Particulates of Downtown Montreal (Data from extraction and chromatographic adsorption analysis of 478 mg. of airborne particulates)

| Polycyclic Hydrocarbon | Parts per 100,000 by weight of particulates and smoke |
|---|---|
| Pyrene | 2.3 |
| Fluoranthene | 4.0 |
| 3:4-benzpyrene | 2.3 |
| Coronene | 1.2 |

100,000 parts of smoke by weight, Commins reported values over a range of 2 to 12 at nine sampling sites in Liverpool for the first three hydrocarbons shown in Table VI.

It is clear that lung cancer in relation to air pollution represents a problem that involves exposure of people to a polluted environment over many years. The amount of potential carcinogenic hydrocarbons that may be accumulated in the lungs over one or two years may still be too small to be biologically significant but the clinical picture can be altered quite substantially if the period of exposure is prolonged over several decades or a lifetime. In addition, one cannot overlook the possibility that other airborne pollutants and irritants may enhance the toxicity of such polycyclic hydrocarbons by a process of activation or by slowing up the normal rate of removal of these substances from lung passages by the mucous and cilia, thus intensifying their contact with sensitive membranes.

#### *Exhaust from Motor Vehicles*

The exhaust fumes from motor vehicles in urban centres constitute a growing air pollution hazard. In Los Angeles County, the exhaust products from three million motor vehicles are regarded as the major, uncontrolled source of smog. Heavy concentrations of motor vehicles exist in the urbanized quarters of many other cities of North America. It has been estimated by the Los Angeles County Air Pollution Control District that for every 1,000 gallons of gasoline consumed in automobile engines there are discharged in the exhaust gases about 200 to 400 pounds of hydrocarbons, 3,200 pounds of carbon monoxide, 25 to 75 pounds of oxides of nitrogen, 18 pounds of aldehydes and 17 pounds of sulphur oxides. An additional quantity of about 100 pounds of hydrocarbons is released to the atmosphere per 1,000 gallons through handling, marketing, and evaporation of gasoline.

Hydrocarbons and oxides of nitrogen may undergo photochemical reactions in sunlight to produce reaction products that cause eye irritation phytotoxic effects on vegetation, and accelerated cracking of rubber goods. It is known that ozone is formed as a by-product in the photolysis of oxides of nitrogen. The ozone reacts rapidly with olefines and other unsaturated hydrocarbons released in the automobile exhaust to produce "oxidants" or ozonides and peroxides of hydrocarbons, aldehydes and many other intermediate radicals and products. Ozone, in itself, has been shown in animal experiments to stimulate excessive growth of connective lung tissue and to scar the lung tissues. The animals in the above experiments were exposed to 1 p.p.m. of ozone for six hours per day during a period of one year. Other effects of ozone exposure may lead to pulmonary edema or disturbance of the alkaline phosphatase levels in the body of experimental animals. On the other hand, the repeated inhalation of low, harmless, concentrations of ozone appeared to develop a significant degree of resistance to the acute effects of later exposures at heavier concentrations.

It will be noted that carbon monoxide is present in the automobile exhaust in a quantity much greater than that of any other contaminant. Carbon monoxide produces toxic effects in the body by two main pathways. First, by combining with the haemoglobin of the blood at a rate that is 210 times greater than that of oxygen, it renders the haemoglobin, thus attacked, incapable of combining with oxygen. Secondly, this gas alters the characteristics of dissociation of the remaining oxyhaemoglobin so that the latter does not yield its oxygen to the tissues as readily. According to the well-known law governing this reaction, the fraction of the haemoglobin that combines with carbon monoxide and renders it useless as a means of transporting oxygen to the tissues depends upon the relative partial pressures of carbon monoxide and oxygen in the alveoli. At a concentration of 100 parts per million of carbon monoxide in air, the accepted threshold limit value of allowable concentration in the indoor working atmosphere for normal individuals exposed for not more than eight hours per day, the blood becomes saturated with carbon monoxide to the extent of 12.7%, assuming that this takes place at a barometric pressure of 760 mm. and the blood is normally 100% saturated with oxygen.

In many urban centres, exposure to automobile exhaust during driving in heavy traffic may render upwards of 5 to 15% of a person's haemoglobin useless as regards the transport of vital oxygen .Heavy smokers may be affected an additional 3 to 7%. Although the symptom of headache appears generally around the carboxyhaemoglobin level of 20% saturation, susceptible individuals may be affected at lower levels. In persons with heart and circulatory diseases, even slight impairment of the oxygen transport of the blood may have significant consequences.

Of the oxides of nitrogen in motor vehicle exhaust, nitrogen dioxide is relatively, highly toxic. The maximum allowable concentration of $NO_2$ for exposure in the working atmosphere is only 5 p.p.m. and evidence is accumualting that this standard will be reduced to a lower limit in the future. Oxides of nitrogen may produce tracheal and lung damage resulting in lethal effects at sufficiently high concentration within a relatively short time. Nitric oxide combines with

the blood haemoglobin to form methemoglobin, thereby reducing oxygen transport. The combined influence of oxides of nitrogen and carbon monoxide has not been assessed adequately so as to formulate allowable maximum limits of exposure for this mixture of toxic gases, even under occupational conditions. The presence of irritating aldehydes in the exhaust products introduces an additional complicating factor.

The health hazard from motor vehicle exhaust fumes and other sources has led to the enactment of laws in the State of California in 1959 that prescribe standards of air quality. These standards reflect the relationship between the intensity and composition of air pollution and resultant effects on health, such as illness and death of human beings or irritation to the senses, as well as interference with visibility and damage to vegetation. Other standards in these laws define the performance conditions that exhaust fume control devices must meet in order to qualify for state approval. There is now under consideration in the California state legislature a proposal that would require all motor vehicles registered in California to be equipped with approved devices for the control of objectionable components in exhaust fumes. Approved devices must reduce the amount of smog-forming hydrocarbons in the exhaust by at least 80% and decrease the amount of carbon monoxide by at least 60%.

Several types of exhaust purifiers are under development by the automotive industry in Detroit. In the after-burner type, the exhaust gas is treated with additional air, passed through a heat exchanger to raise the temperature of the mixture, and then the hydrocarbons and carbon monoxide in the exhaust are burned in a combustion chamber supplied with spark plug ignition. The combustion products are recycled through the heat exchanger and cooled prior to discharge to the atmosphere. Another type of control device contains a catalyst that promotes combustion of the hydrocarbons and carbon monoxide in the exhaust, and, with additional fuel, removes the oxides of nitrogen as well. A number of practical difficulties must be surmounted before these devices can be perfected to the point where they may be installed at reasonable cost and have a satisfactory service life. Recently, the Automobile Manufacturers' Association of Detroit announced the development of a simple device that costs only a few dollars and returns the fumes that escape normally from the crankcase breather pipe back into the engine to be burned. This would control a source of pollution that consists of unburned gasoline "blowby" from the engine and hydrocarbon oil fumes from the crankcase.

***Air Pollution Research in Canada***

Research at the federal level in Canada on the toxic effects of air contaminants and related problems of sampling, methods of analysis, and identification is centralized largely within the Occupational Health Division of the Department of National Health and Welfare. Divisional activities are organized into two main units of environmental assessment and biological studies. The environmental assessment unit is concerned with laboratory studies and the provision of services to other federal departments, provincial health departments, municipalities, and other agencies in the investigation of conditions that are actually causing or may lead to a health hazard. At the request of provincial health authorities, surveys of air pollution have been organized in a number of Canadian provinces with financial assistance under the Federal Health Grants. Other projects deal with studies of dust and gaseous concentration levels in mines, the extent of environmental contamination by diesel exhaust fumes in railway tunnels, and the investigation of urban or industrial air pollution problems with the co-operation of provincial public health and municipal staff or industry. Air sampling stations maintained by such local and provincial staff are being co-ordinated into a national air sampling network, based on the employment of standardized sampling techniques, in order to correlate information obtained more readily with meteorological and other factors of the environment and to provide basic knowledge for research purposes.

For a number of years, staff of the Division, in co-operation with the Meteorological Branch of the Department of Transport, have been disseminating information to the International Joint Commission and interested governmental and other agencies on the nature and frequency of temperature inversions from continuous measurements made on an 870-foot television tower in the Windsor-Detroit area. This project was originally designed to gather required data in connection with the Windsor-Detroit international air pollution reference. Recently, a 200-foot tower has been installed at the Central Experimental Farm, Ottawa, to aid in the study of air pollution problems and diffusion of pollutants as influenced by temperature, wind speed, turbulence, and other factors.

In view of the importance of polycyclic hydrocarbons, especially those of known carcinogenic potency in relation to lung cancer, a study is being made of the prevalence of such hydrocarbons in the filtered particulates of the urban environment, diesel and gasoline engine exhaust fumes. Methods of isolation and identification of these polynuclear aromatic hydrocarbons by column and paper chro-

matography, spectrophotometry and micro-chemical techniques are an essential part of this project.

Both the chemistry and physics sections of the Environmental Assessment Unit provide essential analytical services in the analysis of gaseous, liquid, and aerosol contaminants especially for provincial health departments. These services involve analytical and micro-chemistry, chromatography, electron microscopy and x-ray diffraction equipment and methods. Only the air pollution phase of the work has been mentioned here, although this Unit carries on a considerable amount of work related strictly to the occupational health field.

The Biological Unit of the Occupational Health Division is concerned with investigations and research problems dealing with the biological effects on health of man by the harmful substances to which he is exposed in his environment. The laboratory studies include the evaluation of the pathological and synergistic or potentiating effects of various mixtures of air pollutants on experimental animals; the changes in enzyme systems of such animals exposed to certain toxic chemical compounds; the metabolic transformation of foreign organic compounds in the body, and the evaluation of the mechanism and rate of transfer of various chemicals across physiological membranes. Here, again, a great part of the work of this Unit deals with morbidity, mortality, lung cancer, epidemiological, and pneumoconiosis problems in the occupational health field.

A considerable amount of laboratory and field survey work in air pollution is being conducted by the Province of Ontario Air Pollution Control Branch under the Director, Dr. C. M. Jephcott. In 1958, Ontario enacted the Air Pollution Control Act and the above Branch was established within the Ontario Department of Health to furnish advice and assistance to municipal officials in the preparation of air pollution control by-laws, in the development of air pollution control programs and in training local staff for this purpose. The Act provides for authorization to investigate or to make the necessary arrangements for the investigation of air pollution problems. Air pollution surveys are being conducted by the Branch in a number of towns in the nickel-copper smelting district of Northern Ontario and in the Niagara peninsula. A special study has been undertaken of particulate pollution levels and of traffic gas contaminants (from vehicle traffic) in the City of Toronto.

Under financial assistance from the Federal Health Grants, a study of the toxic effects of sulphur oxides, oxides of nitrogen and other contaminants on the health of animals is in progress at the University of Toronto. The Nova Scotia Department of Health is conducting a survey of the levels of dust and sulphur dioxide in the City of Sydney as influenced by blast furnace, steel, and coke manufacturing operations. A survey of pollution levels in the City of Winnipeg has been in progress for several years by staff of the Manitoba Department of Health. Specific pollution problems related to processing of sour natural gas, operation of sulphur recovery plants, oil refining, and fertilizer production are being studied by the Alberta Department of Health. The Research Council of Alberta has established an excellent fluorine laboratory for the study of fluoride contamination in water, soil, vegetation, and air in connection with phosphate fertilizer production from sulphuric acid prepared from elemental sulphur, derived from sour natural gas within the province. In the City of Vancouver, British Columbia, a continuing survey of air pollution has been in progress for a number of years, with some assistance rendered under the Federal Health Grants. On the local, municipal level, the study of particulate and sulphur dioxide pollution is being carried out on a systematic basis in Toronto and Hamilton, Ontario.

Among other studies of air pollution in Canada, the most notable are the investigations of pollution levels which have been carried on in the Sarnia, Ontario, district by the Ontario Research Foundation for the St. Clair River Research Committee since 1952; the continuing survey of sulphur dioxide conditions in the Sudbury District during each growing season under the Ontario Sulphur Fumes Arbitrator, Mr. R. H. Murray, and the measurements of air pollution in the Columbia River valley in the vicinity of Trail, and in the Kimberley area, British Columbia, conducted for many years by the Consolidated Mining and Smelting Company of Canada.

Through all these efforts a considerable body of information is being accumulated in Canada on the varied aspects of air pollution in relation to effects on crop plants, forest growth, health of animals and man, meteorology, visibility, and economic factors. The Meteorological Branch of the Federal Department of Transport is developing a specialized program in Air Pollution Meteorology and is assisting the Occupational Health Division in the computing of data on air pollution levels in relation to various meteorological factors. A National Air Pollution Punch Card system has been designed for this purpose.

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REFERENCES will be supplied upon request to Occupational Health Division, Department National Health and Welfare, 45 Spencer Street, Ottawa, Ontario, Canada.

# RADIUM POISONING

## AN OLD INDUSTRIAL HAZARD IN A NEW FORM

LT. COL. W.W. COPPINGER*

Knowledge lies at the root of most problems of hygiene. Usually advances in hygiene result from a patient search for the necessary knowledge. Sometimes, an advance follows as a by-product of knowledge which has been acquired for other purposes. Such an event is here described, an advance which would not have occurred but for the spread of education on the subject of radioactivity.

### The Hazard

It has been found that luminous painted instruments, watch faces and the like can create a serious industrial hazard from the "dusting off" of paint during the use and repair of these instruments. Thus when a watchmaker exposes the dial of a luminized watch he releases a measurable amount of radium in the form of fine dust, contaminating himself and his environment with a highly poisonous radioactive substance.

### Discovery of the Hazard

Preparedness for atomic warfare has necessitated the technical education of specialists in the Armed Forces in the use of the electronic equipment by which radiation may be detected and in the awareness of its manifold dangers. Army units which hold radioactive stores for training and for the calibration of instruments have appointed specially trained officers and non-commissioned officers as "radiation safety officers" who are responsible for the prevention of accidents.

In one of the large base workshops maintained by the Department of National Defence where radioactive material is held for these reasons, the Radiation Safety NCO, one day in January 1948, in the course of casual conversation with the Chief Warrant Officer of the instrument section of the workshop, learned that a large consignment of prismatic compasses had come in for "stripping and refinishing". These terms described the process by which an unserviceable compass is dismantled and the parts scraped and cleaned down to the bare metal, all paint and lacquer being removed. The parts are then repainted and reassembled as rebuilt compasses; new components being added where necessary. On each compass there is a considerable quantity of luminous paint. Since 1948 no luminous painting has been done in army workshops, because it was found to be more economical to utilize civilian contractors specializing in this work than to install the equipment which is required to handle this dangerous paint in accordance with Provincial Industrial Safety regulations. But there are no regulations covering the removal of luminous paint and it had not occurred to anyone that removal of paint might be just as dangerous as its application, perhaps because, as in this instance, removal of luminous paint is not commonly a separate operation in itself but part of a general cleaning process. However that may be, it now occurred to the Radiation Safety NCO, whose job it was to be alert for radiation hazards, that here might be such a hazard. So he went to have a look at this stripping operation and took with him one of his radiac instruments, a Geiger counter, not the best one for this particular purpose but good enough to show that there was, as he suspected, a radiation hazard. He reported the matter to his officers and a full investigation was begun.

### Survey

The first step was to make a survey to determine the extent of this radioactive contamination. Two instruments were used, a 100 watt ultra violet lamp, borrowed from the Magnaflux crack detection equipment in another part of the workshop under whose light phosphorous particles glow, with bright greenish fluorescence. This lamp was used to search for particles of the luminous paint too small to be detected with the naked eye. Radio-activity was proven by means of a scintalator which measures alpha-radiation but is a poor instrument for searching for contamination on account of the

*Commanding Officer, Fort Churchill Military Hospital, Fort Churchill, Man.

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very short range of the alpha particle. In general the contamination was found spread over the whole area indicating that air-borne contamination had taken place. There were areas of heavy contamination on the benches where compasses had been stripped but, surprisingly, the areas of heaviest contamination were found to be in the watchmakers shop and particularly on the watchmakers "aprons", cloth-lined trays over which delicate work is done, where counts as high as 9,000 per minute were found.

Here was quite a new fact. It was to be expected that when luminous paint is scraped off or removed with solvent the dust and sludge would be a source of contamination. But that a serious degree of contamination should occur from the "dusting off" of the paint on watch faces during the course of ordinary watch repairs was not anticipated. Nevertheless the survey proved that this was occurring.

#### *Decontamination*

The first step was to clear up the immediate danger. All work on all luminized equipment, whatever its nature, was stopped. The workmen were immediately evacuated from the contaminated area and decontamination commenced. Two crews of eight men, each working under the supervision of radiation experts trained in the A.E.C. Establishment at Chalk River, set to work. They were equipped with protective clothing and respirators. Tools were cleaned by means of water and detergent agitated by air. The rooms, benches and machines were cleaned by brushing, scrubbing and scraping. It took approximately five weeks to clean the area, but not a single tool or piece of equipment was lost or condemned. Every single thing was decontaminated and taken back into use.

#### *Medical Aspects*

Most self-luminizing paints contain radium (Ra 226) which on account of its radioactivity excites phosphorus, the other component of the paint, to luminescence. The phosphorus element becomes exhausted in a few years and its luminescence rapidly decreases but the radium itself changes very little for the half life of this element is 1620 years. Radium is primarily an alpha particle emitter, although gamma rays and radon gas are also produced. These later could become a danger to health if radium-containing paint in substantial quantities were concentrated in one area, and oddly enough this fact was known and regulations concerning the storage of quantities of luminized equipment had been issued some time previously, although the much greater danger now discovered had been overlooked.

The danger of an alpha emitting element is of a different nature. Its radiation is not harmful externally except in case of severe contamination, but internally it is a dangerous poison. Radium in the body behaves in a similar manner to strontium, whose poisonous character is now widely known from the publicity given to the danger of "fall out" from thermonuclear bombs.

Like strontium, radium, if absorbed into the body, is metabolized in a manner similar to the element calcium. It becomes concentrated in the bones close to the active marrow where blood cells are formed. These are areas where alpha radiation can do most damage. Alpha particles, though they have litle power of tissue penetration, are strongly ionizing; 10,000 times more powerful in this respect than gamma rays. Once established in bone, the element is very slowly eliminated. Medical treatment to accelerate this elimination has not so far met with much success. It is this combination of slow biological turnover and long atomic half life which makes this element and strontium particularly dangerous. Fortunately it does not seem to be easily absorbed, but not enough is known to allow any complacency on this score. Among several possible routes of absorption two are probably of prime importance, ingestion and inhalation. Both are much influenced by the physical size of the particulate matter and by the solubility of the salt which contains the radioactive element.

The results of radium poisoning are known precisely only when the amount is large enough to be fatal in a short time. From smaller doses two serious effects can be expected, an increased incidence in malignant disease and an increase in the genetic mutation rate.

The latter effect has received much publicity from the debate as to whether or not further thermonuclear bomb testing is justifiable, but is probably of little importance when the poisoning of a few individuals rather than of whole populations is under consideration.

Both radium and strontium in the body quite certainly can promote neoplastic change, but whether there is a certain threshold of internal radiation below which this change does not take place or whether there is a progressive increase of disease proportional to increasing radiation is not known. Until this is established, a provisional standard has been set. This is stated as a maximum permissible body burden of 0.1 micro-curie. It is estimated that this amount will not cause any measurable ill effects and is probably valid, despite the unknown factors which have been mentioned above.

The "body load", the total amount of radium in

the body, is estimated very simply by measuring the amount excreted over 12 hours. As the rate of elimination is proportional to the amount present, the amount remaining can then be readily estimated. Bio-assay was carried out on all those personnel who were judged to have been in danger. Seven of them showed a measurable amount of radium poisoning but in no case was the permissible body load reached. Thus, it was proved that the danger with which we were dealing was real but that, as far as this workshop was concerned, no irreparable harm had come of it.

Since each compass may carry about 7 microcuries of radium in the form of paint, seventy times the "maximum permissible body load" for one man, and since many hundreds of compasses and watches had been processed through this workshop, either these men were very fortunate or the safety factor due to poor absorption is high.

#### *Further Survey*

While decontamination was in progress, further survey came to a halt as all available ultra violet lamps and instruments were in use, but once decontamination was over further survey was carried out. It was found that similar conditions occurred in other smaller workshops wherever instruments or equipment with luminized dials were repaired, that it was present in stores where the luminized components of these kits were kept and whence they were issued and that it was even to be found in unit quartermaster stores and indeed wherever that ubiquitous item, the prismatic compass, was to be found.

#### *Development of Safety Measures*

It was clear that there were two aspects of the problem of safety. Firstly it was necessary to make such arrangements in the workshops that contaminated luminized instruments and equipment could be handled in safety and secondly to treat the luminous paint on these instruments and equipment in such a way that it would be thereafter safe for ordinary use without special precautions.

After an interlude, due to the mistaken belief that all an instrument maker required was a clean sheet of paper on his bench each day, which ended abruptly when an area already decontaminated had to be done over again, serious work on the development of safety precautions began and took a year to complete.

In brief the method evolved was to clean up the contaminated article inside a box from which the poisonous dust cannot escape then seal the remaining paint under a coat of transparent plastic so that it will "dust off" no more.

Cleaning is carried out either by dry brushing or by washing with a suitable cleaning fluid. Once cleaned, all luminous painted surfaces are sprayed with plastic varnish. The cleaned and proofed article can then be removed from the box and put into the repair organization without danger to anyone.

Three sizes of these boxes have been manufactured and tested. They vary in their complexity with their size. The largest is a complete portable room in which very large equipments can be decontaminated, the technique used being very similar to that utilized for decontaminating any large area. The operator works inside the room and wears a complete set of protective clothing and a respirator.

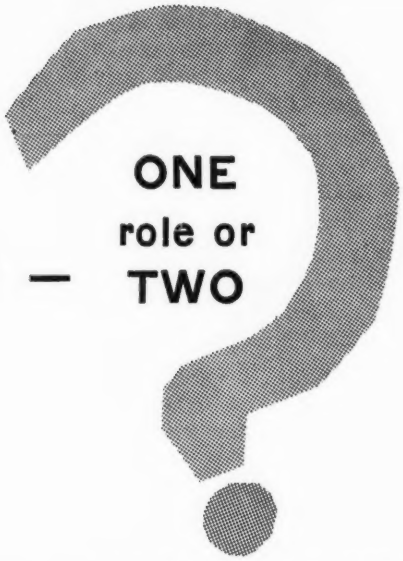
The next size down is a large "dry box" a cabinet 40 inches x 30 inches x 20 inches so made that when the doors are closed it is completely sealed. The operator works through holes in the front which are fitted with sleeves and rubber gloves. The unit includes a powerful ultra violet light, a filtered exhaust system and an automatic flushing system by which special cleaning fluid is sprayed over the inside of the box and washes all contaminant into a filtered sump before the box is opened.

All controls are foot operated so that the operator does not have to remove his hands from the sleeves in course of operations. This cabinet is large enough to handle quite bulky equipment such as large radio sets but its principal use is in "stripping", which, as has been seen, is a dangerous operation unless very strictly controlled. A large cabinet like this is expensive to manufacture but is only required in large workshops. For ordinary everyday use in the instrument shops which handle the great bulk of luminized articles a much smaller and simpler cabinet is satisfactory. This cabinet and its associated equipment has been manufactured and issued to army workshops in Quebec Command under the name of "Kits radiation detection and decontamination". This kit is described in detail because it will no doubt, have a much wider application than that for which they are at present manufactured. The cabinet is not a sealed "dry box", part of the front is open and through this opening the articles to be decontaminated are introduced and handled. To prevent radioactive dust escaping through this opening an exhaust system is fitted to the cabinet, providing a slow updraft of air which creates no turbulence but which prevents any "spill" of airborne particles from the cabinet. A 0.3 micron filter is placed in the exhaust system which removes all radioactive particles.

The cabinet is equipped with a blackout canopy

(*Continued on page 26*)

# The Coach and the Counsellor — ONE role or TWO



BY C. R. BROOKBANK*

The question in the title of this article may appear to some people as academic. To many supervisors in industry it is anything but academic because of the fact that "coaching and counselling" account for a great deal of discussion in supervision today. The terms are usually used synonymously.

Perhaps there was a time when the medical doctor, the clergyman and the lawyer were among the few professional people who required counselling skills as part of their modus operandi. With the steady increase of professionalism in our society, the counselling role has become part and parcel of the leader's function in many other areas.

Counselling would probably be defined by most people as "giving advice". Those who have a direct responsibility for raising children know there are many ways of doing this. Advice-giving is a key function in any leader-follower relationship, and the supervisor in business or industry is well aware of this. In his mind, however, giving advice may be much more closely related to giving direct orders than to counselling as he understands it.

Many supervisors have the feeling that counselling implies performing as an "amateur" psychiatrist. They have the impression that counselling is, for the most part, non-directive and involves a "permissive" relationship. Aside from the fact that these are unfamiliar terms defining rather awkward and uncomfortable circumstances for the supervisor as he sees it, they also leave him with the impression that he must explore personal areas which are really none of his business while maintaining a non-judgmental attitude about the circumstances.

The supervisor who feels this way may be right, or he may be wrong, but two things are reasonably certain. He is not stupid and he will not use a method which makes him uncomfortable or which he does not regard as legitimate to his function.

Many supervisors find the word "coaching" much more acceptable to them, perhaps because it suggests some rather subtle but important differences from "counselling". It is my intention, in this article, to attempt to define some of these differences. While these may be mainly differences in degree rather than in kind for the person of academic orientation, they may help to define the "rights and responsibilities" of both parties in everyday coaching or counselling situations.

In the first place, coaching involves a much more direct relationship with others beyond an immediate coaching situation. In a coaching circumstance, several individuals with mutual objectives may be coached by the same person. The coach then has a relationship not only with each individual, but is also concerned with the interaction of the total group. Examples of this can easily be visualized in athletic games or work units.

In a counselling situation, there is usually a more indirect relationship between the counsellor and other persons closely related to the counsellee. The counsellor may never see other individuals who may have a close relationship to the person whom he is counselling. Under these circumstances, his understanding of how these other people may affect the counsellee — and vice versa — may be much more indirect and vague. The coach, then, is more often in a position to bring direct influence and sup-

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port to the person being coached than can the counsellor to the person being counselled.

In coaching, the focus of an interview should be on the performance of an individual rather than on the individual himself. Discussion is focussed mainly on overcoming performance problems with the result that subjective and emotional attitudes can be more effectively subdued.

In counselling, the focus is primarily upon the person being counselled and upon problems which he considers as personal. There is probably a much higher degree of introspection and a greater focus on factors which may not bear directly on immediate action to resolve the problem.

There are few circumstances in which a coach does not find himself in a position of direct leadership. In contrast to the counsellor, the coach will usually have power to affect the behaviour or welfare of the person under his coaching supervision. In addition, the coach has a status based on the direct authority of his position.

As a general rule, the counsellor does not have this direct power although he may have a status with the counsellee based on his role as a specialist. Aside from the respect which he may command because of his status, the counsellor rarely has power to affect the ultimate behaviour of the counsellee.

In the absence of such direct power, the counsellor may attempt to use more indirect methods of influence and these could become a substitute for power. For example, by pointing out dangers to personal health, possible reprisal by the community for immorality, religious condemnation, or similar undesirable results of ignoring the counsellor's advice, the counsellor can develop substitutes for direct power. On the other hand, the coach may try to minimize the power aspect of his relationship with the individual, but it is doubtful that it is ever completely ignored. In any individual situation, the coach is better advised to admit his direct authority and discover whether it brings a greater response or a greater reserve from the person being coached. This power must be used wisely, but to imply that it is non-existent is to run the risk of being regarded as insincere by those under the coach's supervision.

A coaching relationship is usually a continuous one. More important, it is a normal part of a leader-follower relationship, especially in a democratic society. The leader who takes the time and effort to coach, is a leader interested in the development of individuals as well as in getting the job done. The coaching relationship may be duplicated, for the most part, year after year with different groups of followers and with relatively minor variations.

The counselling relationship seems to be more often a unique and temporary one. It is not expected to continue over a period longer than is necessary to resolve the problem of the counsellee or to enable him to function independently of the counsellor. Most leaders do not have counselling as a regular part of their function, whereas coaching is an integral part of the leader's role. People expect to be coached by a leader but they do not usually expect a high degree of personal counselling. The coaching relationship does not end until mutually accepted objectives are achieved. Whereas in counselling an effort is made to make the counsellee independent of his counsellor, an important objective in coaching is to build a stronger understanding and continuing relationship between the individuals involved.

In the coaching relationship, the primary emphasis is on moving the self-concept closer to the real self. In the counselling relationship, the major emphasis is on searching and exploring the real self with a view to re-organizing the self-concept. Let me try to explain this in more detail.

Each individual has a concept of himself which may or may not coincide closely — but never completely — with his real self. This premise must be based on the assumption that it is virtually impossible for any individual to conceive, consciously and completely, the intricate totality of his real self. In relation to this premise, coaching involves helping the individual to test these abilities *which he thinks he has.* It does not presume *major alterations* in the individual's concept of himself. Counselling, on the other hand, may involve helping the individual to overcome personal fears or tensions and indeed to *revise* his concept of himself and his capabilities.

The emphasis in coaching is more often upon "how to accomplish" rather than upon "should or can you accomplish". The emphasis in counselling is more often upon "should you act" or "can you accomplish" rather than upon "how to achieve". In my opinion, these are important differences *in depth.*

The application of specific and measurable standards, which can be applied directly, is more easily achieved in a coaching relationship — where future performance can be judged as a direct test of the value of coaching — than in the case of a counselling relationship, where the results are usually more intangible and the behaviour change primarily internal. It is usually easier to measure the results of coaching than it is to do so with the results of counselling. A coach has the chance to observe his people in their direct attempts at

*(Continued on page 25)*

# Review of Dust Assessment Techniques

BY C. R. ROSS, M.S., P.Eng.*

### Introduction

The assessment of pneumoconiosis-producing dusts in mines and other industries is usually undertaken for one or more of three reasons:

(1) To compare dust exposures at particular operations with standards of permissible dustiness in order that hazards may be evaluated and preventive procedures initiated where required.

(2) To study particular operations with the objective of improving dust control devices or procedures by locating dust sources.

(3) To obtain data which, along with the results of medical investigations, may assist in understanding the causes of dust-induced diseases or aid in the establishment of permissible standards of dustiness.

Most dust measurements are made for the first of these reasons — to evaluate dust hazards so that they may be controlled. For this purpose, four quite different assessment techniques have been in widespread use for many years. One of these is based on the konimeter, an instrument familiar to most Canadian mining men; a second on the impinger, which is also widely used in Canada, and almost exclusively so in the United States; a third on the thermal precipitator, used extensively in Britain and South Africa; and a fourth on the tyndallometer, a light-scattering instrument used in Germany.

Each of these methods has particular advantages which have led to its adoption and each has performed valuable service in controlling pneumoconiosis. All, however, have limitations which make it difficult to compare results of surveys by different techniques, and none has such superior qualities as to make it attractive for universal adoption.

Where the purpose of dust measurement is to locate dust sources, assessment techniques are sometimes simplified to give an indication only of order of magnitude, and specialized techniques — particularly motion-picture photography and radioactive tracers, — have proven useful in pin-pointing dust sources and in studies of the diffusion of dust clouds.

TABLE I. — Permissible Standards of Dustiness in British Coal Mines

| | | |
|---|---|---|
| (i) | For coal dust clouds in anthracite collieries | 650 particles/cm³ between 1.0 and 5.0 microns in size |
| (ii) | For coal-dust clouds in other collieries | 850 particles/cm³ between 1.0 and 5.0 microns in size |
| (iii) | For stone drifts and hard headings in all collieries | 450 particles/cm³ between 0.5 and 5.0 microns in size |

For research investigations which require correlation of environmental data with pathological findings, sampling is more extensive and data gathered on the nature of airborne dust and associated air contaminants is more detailed. Particle size measurements are commonly made in such studies.

### Dust Assessment for Control of Dust Hazards

#### *Thermal Precipitator*

Of the four instruments for dust concentration measurement used most widely for routine surveys, the thermal precipitator has the reputation of being the most accurate, but not the most convenient. Precipitation by the precipitator is based on the fact that a dust-free area surrounds a heated body and, in its most common form the instrument consists of a heated wire mounted between two microscope cover glasses. Air is drawn through the apparatus for a period of minutes or hours and particulate matter is deposited on the glass slides, which are subsequently examined under a microscope. Particles of all sizes are collected in essentially the same form as they are present in the air and there is no problem of breakdown of particle agglomerates or shattering of particles. However, overlapping of particles on thermal precipitator slides may sometimes give dust counts

*Occupational Health Division, Department of National Health & Welfare, Ottawa.

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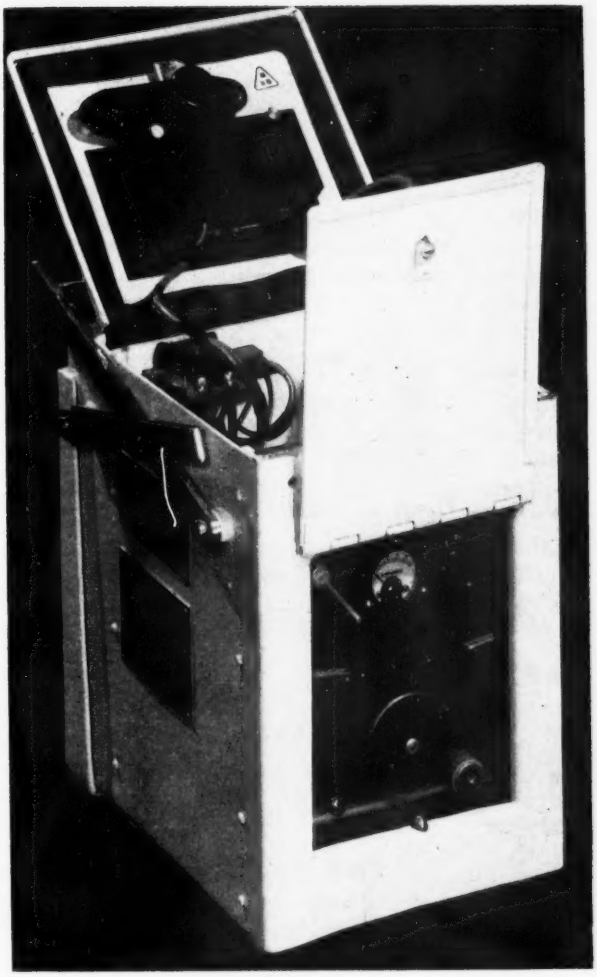

**Figure 1.—Long-running thermal precipitator.**

much below true counts (1) and, while the instrument is most efficient in the collection of very fine particles, the utility of counting such particles is doubtful because atmospheric pollutants normally present in the air tend to obscure changes in the concentration of particles generated by the dust-producing process (2). Particles below one-half micron are not routinely counted in England.

The thermal precipitator is an integrating instrument which yields an estimate of the average dust concentration at a sampling point during the period of sampling. British standards of permissible dustiness for coal mines are interpreted on the basis of samples collected at an operation throughout the working shift, excluding stoppages, and vary from 450 to 850 particles per cubic centimeter.

A thermal precipitator which collects a single air sample over an eight-hour interval is coming into routine use in England (Figure 1). It is designed

**Figure 2.—Freon-powered midget impinger.**

to be left unattended at a fixed point in a mine, as for example the return end of a coal face where dust concentrations may be higher than at other points along the face. Dust is collected by a combination of gravity settling and thermal precipitation which results in a deposit on the glass slide graded in order of particle size. At present, particles are counted by conventional microscope techniques, but a photo-electric assessment method is under development. It is hoped that such an instrument will reduce the burden of routine dust assessment, which now requires the National Coal Board to employ 400 dust samplers and 200 laboratory staff on routine dust assessment (3).

### *Impinger*

The impinger, like the thermal precipitator, is an integrating type of instrument. Air is drawn through a nozzle at high velocity and strikes a plate at a fixed distance from the nozzle. The dust is trapped in a liquid which is subsequently examined under a microscope. The efficiency of the impinger for particles below one micron in size is low, but as permissible standards of dustiness used with it are based on particles between one and five microns, this is unimportant. It does break up agglomerates and will shatter particles, and these effects may give erroneously high counts in some cases. The convenience of the impinger sampling

method has been improved recently with the introduction of a light-weight freon-powered ejector (4) (Figure 2).

A knowledge of the quartz content of the dust is essential to the interpretation of impinger results. In most cases the quartz content may be determined on either parent material or airborne dust. Airborne dust samples are preferred and large samples are usually collected on filter material with a modified vacuum cleaner. A compressed-air-driven instrument of this type has been developed by the Department of National Health & Welfare for use in mines. Samples are subsequently analyzed by X-ray diffraction or chemical methods, usually after size fractionation.

Samples of dust collected on filters include individual particles as they existed in the air, agglomerates as they existed in the air, and agglomerates formed on the filters. As size fractionation procedures cannot differentiate between agglomerates formed when dust is laid down on filters and dust which has been laid down in an agglomerated form, the material finally analysed may not be truly representative. A new British instrument eliminates this problem by collecting only respirable dust (Figure 3). Air is drawn through closely spaced horizontal plates at a velocity which causes larger particles to settle out. This instrument is known as the Hexhlet dust sampler and was developed in England by B. M. Wright of the Medical Research Council (5). It is illustrated in Figure 3.

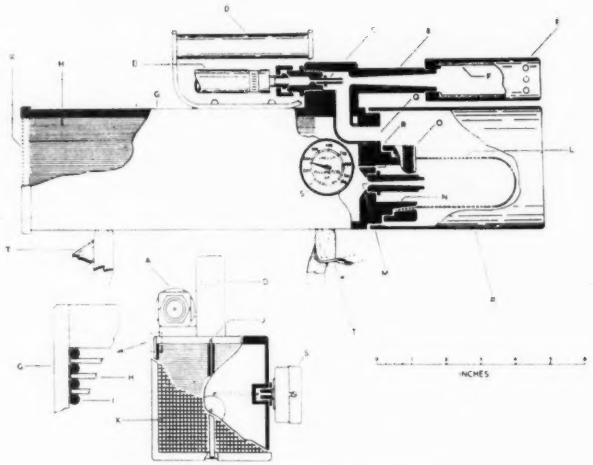

**Figure 3.—Hexhlet air sampler.**

#### *Konimeter*

The konimeter collects dust by the same principle as the impinger but collects it dry on a glass slide. Like the impinger, it will shatter some dust par-

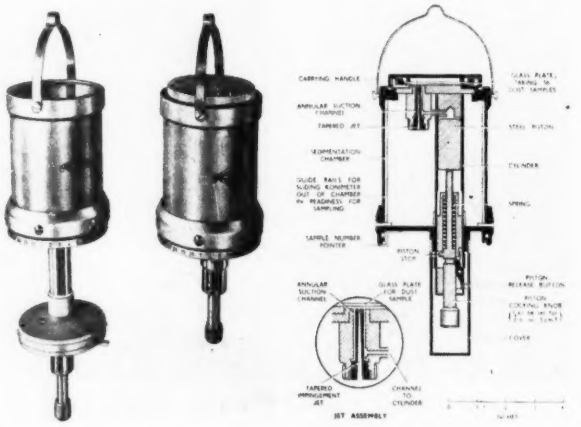

**Figure 4.—Sartorius mining konimeter. Shows chamber both open and closed.**

TABLE 2—CLASSIFICATIONS IN GERMAN ROUTINE MEASUREMENTS OF AIRBORNE DUST

| Dust level | Dust concentration by Tyndalloscope ($k$) and rough equivalent in $p/cm^3$, 1–5$\mu$ size range | | | | | | Maximum interval between sampling, weeks |
|---|---|---|---|---|---|---|---|
| | 0–20% ash | | 50% ash | | 100% ash | | |
| | $k$ | particles/cm³ | $k$ | particles/cm³ | $k$ | particles/cm³ | |
| I. Low .. .. | 0–25 | 0–250 | 0–10 | 0–75 | 0–5 | 0–25 | 26 |
| II. Medium .. | 25–50 | 250–500 | 10–20 | 75–150 | 5–10 | 25–50 | 13 |
| III. High .. .. | 50–100 | 500–1 000 | 20–40 | 150–300 | 10–20 | 50–100 | 6 |
| IV. Very high .. | >100 | >1 000 | >40 | >300 | >20 | >100 | 3 |

ticles, break up agglomerates, and is inefficient in the collection of particles less than one micron in size. It differs from the impinger and thermal precipitator in that it is an instantaneous sampler and a series of samples must therefore be collected at each operation in order to establish average concentrations. There is an advantage in instantaneous measurements, of course, in that a record is obtained of how the dust cloud varies during the course of an operation. It is the most convenient sampling instrument to use in the field. Current Canadian practice in konimetry has been described recently by Andrew. (6)

In German coal mines the konimeter is used not to measure concentration but to obtain an estimate of the non-coal fraction of the dust. (7) This is done by examining microphotographs of konimeter spots before and after ashing or by examining the spots visually under special illumination. A konimeter equipped with a pre-settlement chamber is employed in order to eliminate coarse dust. This instrument is illustrated in Figure 4.

#### *Tyndallometer*

The tyndallometer measures the degree of light-scattering created when a beam of light is directed through an air sample. In Germany such an instrument is used along with the konimeter to determine the degree of respirable dust hazard (7). It is a convenient instrument to use and permits a complete and rapid assessment of working places, but it is affected by airborne salt crystals and oil droplets which may lead to an over-estimation of dust hazards. Also it over-estimates concentrations of very fine dusts. Instruments designed to overcome these problems and also recording types are under development. The instrument in current use is illustrated in Figure 5. German dust standards are used to control the frequency of sampling, as shown in Table II. Particle counts in this table are approximate comparisons of tyndallometer readings ($k$) with thermal precipitator results.

#### *Standardization of Techniques*

In a paper published in 1937 describing dust assessment procedures in Ontario mines, Norman (8) expressed the hope that it would "soon be possible to get those responsible for dust determination in various locations and countries to join together in an effort to evolve a more universal standard procedure for practical routine dust sampling", and went on to say that the procedure should have "some reasonable relation with research measurements and measurements made by different countries" and that the apparatus should be "simple, portable, easy to operate, and reliable". These same

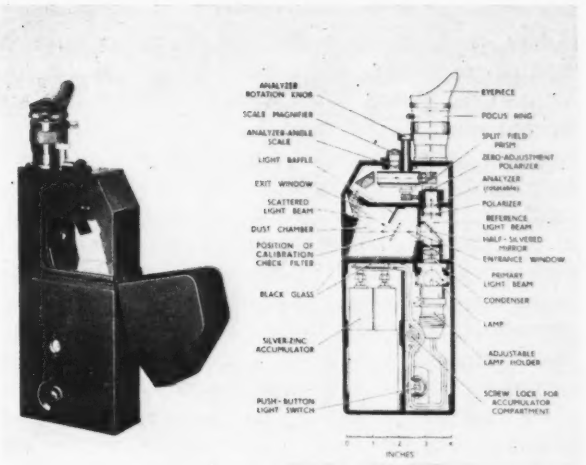


**Figure 5.—Leitz tyndalloscope.**

hopes are expressed in papers published on dust control today and the fact that no universal standard procedure has been evolved despite some considerable efforts over the last twenty years serves to underline the complexity of the problem.

In part, the failure to develop a universal standard is related to the great mass of data which individual dust control organizations have accumulated with particular instruments and which permits them to interpret the results of their investigations effectively. Unless results with a new instrument could be directly related to the one in current use, much valuable experience would be lost.

Another important reason why a universal dust assessment procedure has not been developed is the difficulty of measuring directly the parameters of the dust cloud which are believed to be primarily responsible for lung damage. For example, one recommendation of the International Pneumoconiosis Conference (9) held in South Africa in February of this year (1959) was to the effect that the best single parameter to be measured in the case of coal dust was mass concentration of the respirable dust, and in the case of quartz dust to be the surface area of the respirable dust. Neither of these measurements is made routinely in any country today. Nagelschmidt (2) has stated the reasons why this is so as follows:

(1) There is no convenient method known at present for measuring the quartz surface in a cloud of mixed dust particles where the quartz is too small to be identified by conventional petrological techniques;

(2) It is easier to isolate dust from a small volume of air and to count it under the microscope than to sample such a large volume of air that the dust could be weighed.

### *Dust Assessment for Research Purposes*

A large-scale research study of pneumoconiosis in British coal mines is a current project of the National Coal Board (3). Medical observations are being made on 35,000 men in 25 selected coal mines, together with systematic dust measurements. This investigation is expected to last about ten years and one result is expected to be better dust standards. The assessment technique for this project differs from British control techniques primarily in degree and consists of routinely measuring dust exposure of occupational groups at each mine with the thermal precipitator. These groups consist of men doing the same work at the same place at the same time and vary at any one colliery from twenty to one hundred groups. The exposure index of the group is assessed by selecting at random a number of representatives of the group and measuring their dust exposure throughout their working shift. The measurement procedure differs from the control sampling procedure in that samples are collected whether or not work is in progress and, during evaluation, an estimate is obtained of the proportion of coal and non-coal particles in each sample. Compositional analyses are also made on material collected with the Hexhlet dust sampler.

The results of a comprehensive investigation of pneumoconiosis hazards in the diatomite industry were published recently by the U.S.P.H.S. (10). The assessment technique employed in this survey consisted of the measurement of dust exposure by the standard impinger method, analysis of parent material, settled dust, and airborne dust for determination of physical and chemical properties, and particle size determination of samples collected on membrane filters. No attempt was made to measure exposure of workers throughout their working shift. The number of atmospheric samples taken at any specific activity was governed by operational variation, range of dust counts obtained, and by the number of employees engaged in a specific area or task. Samples were taken on different days and during all three work shifts. This survey resulted in a new dust standard for this industry.

### *Development of Dust Control Devices*

In practical investigations where it is the aim to improve dust control at a particular piece of equipment or in a particular process, standard dust techniques may be employed or, in some cases, such techniques may be simplified to permit large numbers of samples to be examined. Standard methods were used in a large-scale investigation carried out a few years ago by the Mines Accident Prevention Association of Ontario which resulted in improvement in drilling dust control (11). Abridged methods have been used in the British foundry industry.

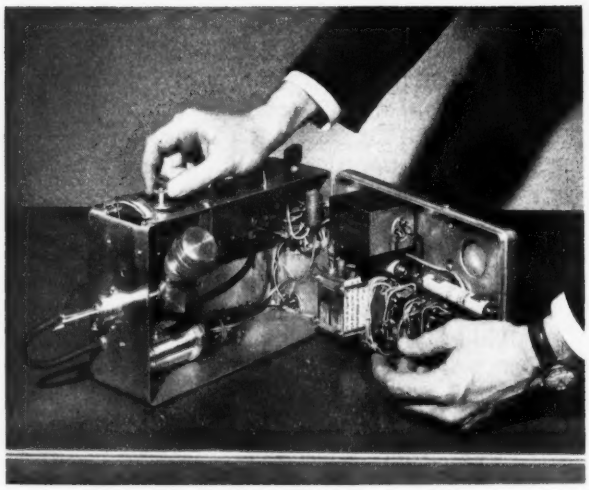

**Figure 6.—Southern Research Institute aerosol photometer.**

One of the most interesting techniques to be employed for this purpose is the illumination method developed in England by Lawrie and associates. (12) It consists essentially of illuminating an operation with a high-intensity light beam and photographing the moving dust cloud with a movie camera. The method makes it possible to determine points of origin of dust and to follow the path and diffusion of dust plumes. By studying the films the work of developing dust control devices is greatly simplified.

The dispersion of clouds of respirable dust by mine ventilation systems has been studied in England by means of a radio-active tracer technique (13). As respirable dust acts essentially as a gas in the way it mixes with air, a radioactive gas could be used as a tracer. In this study, radioactive methyl bromide was released from a cylinder to simulate a point dust source and measurements of radioactivity were made at a considerable number of points downstream. With this method, a continuous record of the airborne concentration could be obtained at any point. The pattern of diffusion was found to be independent of airspeed but to be directly related to the airflow resistance. Complete mixing was found to take from 10 to 100 gallery diameters.

### *New Developments in Dust Assessment Techniques*

New equipment is continually being introduced which, it is hoped, will simplify or improve dust assessment techniques. For example, experimental work is proceeding with a number of automatic particle-counting devices which depend on scanning the microscope slide with a tiny beam of light (14). Another automatic instrument counts and sizes particles by measuring the change in con-

ductivity when particles, suspended in a liquid, pass through a small orifice. A very compact photoelectric particle sizer and counter developed by the Southern Research Institute is used in some American coal mines (15). It weighs only 10 pounds and is battery-operated. (Figure 6)

The membrane filter, now used routinely for radioactive dust assessment, is attracitve for dust counting because particles are laid down on the filter surface in the form in which they are present in the air, very simple sampling apparatus can be used, and particles may be examined directly under the microscope by making the filter transparent in cedarwood oil. In the U.S.P.H.S. diatomite survey an attempt was made to use membrane filters to collect dust samples for counting, but it proved unsatisfactory because the silica particles were transparent under the cedarwood oil. Limited studies indicate it to be satisfactory for coal dust measurements (16).

Whatever improvements are made in dust assessment techniques in the future the most important element in dust control investigations will remain the patient observation by an experienced observer. This, in my opinion, is the one essential feature of any dust study and is what has enabled so much to be accomplished in the prevention of pneumoconiosis despite uncertainties surrounding the measurement techniques.

References will be supplied upon request.

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## THE COACH AND THE COUNSELLOR — ONE ROLE OR TWO ?

(*Continued from page* 19)

application; this is usually more difficult for the counsellor because his opportunities to accompany the counsellee into the "arena of life" are more rare.

One of the most important operating differences between coaching and counselling arises from the fact that coaching is initiated by the coach, whereas counselling is initiated by the counsellee. Coaching is the legitimate and expected function of the coach — a part of his job. If the individual being coached is reluctant to respond, the coach is within his right to pursue the problem and call the individual to account.

In the counselling relationship, the initiative should be with the person being counselled and exploration of the problem should be at his discretion. If the counsellee does not seek the counsel, any attempt by the counsellor to initiate such a relationship could be interpreted as an invasion of privacy and an imposition upon the counsellee. In short, coaching involves the legitimate use of authority, while counselling may constitute an abuse of authority unless it is initiated by the counsellee. Confusion and uncertainty about these differences in relationships account for a great many of the problems which arise in the minds of supervisors in industry faced with the task of appraising employee performance.

In coaching, judgments are usually made prior to the interview, even though such judgments may still be subject to alteration. Pre-interview judgments are possible because the coach has a chance to observe the performance and the behaviour of the individual prior to the coaching interview. If the judgments of the coach involve standard and time-tested procedures which are applicable to the situation, such judgments may be justifiable and expected.

In counselling, judgments must await evidence which comes to light in the course of the interview, although a counsellor may begin with certain preconceptions based upon his own background or experience. Such may be the case with the physician, lawyer or clergyman. However, it is difficult and perhaps even dangerous for the counsellor to apply "general" solutions, since the counselling relationship is usually much more individualized than the coaching relationship. The counsellor often has little or no chance to observe the performance or behaviour of the counsellee prior to the interview, and consequently he must rely to a much greater extent on the interview as the basis for his appraisal of the problem or situation.

In the coaching situation, *mutual* objectives can be assumed in connection with the game, the job or whatever project brings the coach and his "trainee" together. The *primary* focus is on that part of the trainee's life which is involved in the project. Other aspects of his life come under consideration only insofar as they also have a bearing on the project. In counselling, where the problem does not *directly* involve the counsellor, the focus is primarily on the counsellee and his ability to cope with his own total environment.

In summary, the differences between coaching and counselling outlined in this article may suggest that the *relationship and role* of the coach — in the sociological sense — is not precisely that of the counsellor. In industry, the supervisor is always a coach and occasionally a counsellor. If he is to be an effective coach, he must understand his coaching role and the nature of his relationship with subordinates. Coaching is not casual; it is the essence of supervision.

(*Continued from page* 17)

under which the operator can stand and with built in sources of both white and ultra violet light so situated that the article being decontaminated can be brought within 2 inches of the source without the operator being exposed directly to ultra violet light.

There is sufficient space inside the cabinet for the operator to work properly and with economy of time. He can for example decontaminate a batch of several articles at a time. He has at his disposal a sump for cleaning solvent which can be used for wet decontamination and if necessary for decontamination of the cabinet itself. He has also a disposal facility in the shape of a plastic bag into which can be dropped contaminated material such as containers, tape, paper, etc., which is disposed of in accordance with the procedure for radioactive waste. This cabinet with its blackout screen can be set up anywhere without interfering with the surroundings; for it requires little space, and operates from two ordinary 110 volt outlets.

The operator is provided with a minimum of protective clothing in the shape of overboots and apron. Owing to the exhaust ventilation of the cabinet there is no need for him to wear a respirator. In addition to this clothing and the complete cabinet, the "Kit, radiation, detection and decontamination" includes two drums to contain radioactive waste — wet or dry, and a 100 watt portable ultra violet lamp which is used to monitor the whole area used for decontamination to ensure that no "spill" is occurring.

The complete kit, including all its accessories, costs approximately $300. It is entirely suitable for use in all watch repair establishment, civil or military.

**SUMMARY**

An industrial hazard from the "dusting off" of radioactive luminous paint during the normal course of watch and instrument repair has been discovered and the development of a method of controlling this hazard is described.

The equipment required is inexpensive and the control techniques and personal hygiene regulations are simple, easy to learn and to maintain.

The hazard described, that of radium poisoning, is probably quite widespread, and the effects of this poisoning are so insidious that their true cause is unlikely to be recognized. Since there is no cure once poisoning has occurred, this is a field in which preventive medicine is of great importance.

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# OCCUPATIONAL HEALTH REVIEW

"The program of the Occupational Health Division is concerned with service, research and education in the field of Occupational Health, and of Air Pollution in Canada.

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